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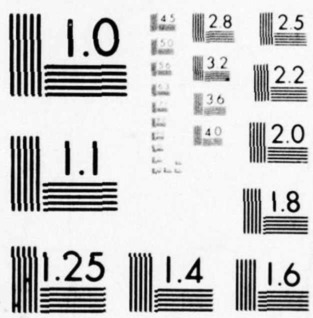

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ANALYSIS OF LARGE REQUISITIONS

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February 1977

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Philadelphia Pa. 19106

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ANALYSIS OF LARGE REQUISITIONS

FINAL REPORT

BY

ARTHUR HUTCHISON

FEBRUARY 1977

DRC INVENTORY RESEARCH OFFICE
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Maximum release quantity
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A model at both the wholesale and retail level based on an item's average issue quantity is shown to be effective in identifying large and possibly erroneous quantities requisitioned. The following performance indicators substantiated the choice of this model over several tested: excess dollars captured; erroneous requisitions identified; rejection of valid quantities; and dollar savings based on a cost evaluator.

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Mr. Alan J. Kaplan, DRCIRO, contributed significantly in all areas of this work.

SUMMARY

Currently there exists a model at the wholesale level based on an empirical estimation of the item's variance to mean ratio to determine the maximum quantity to be issued to the NICP's customers. The purpose of this study was to develop models and procedures which would effectively prevent the issuing of large erroneous quantities and reduce the number of invalid rejections attributed to the current model.

Several models were tested and assigned cost to ascertain the best editing system. Results indicate a model at both the retail and wholesale levels based on the item's average issue quantity assuming a geometric distribution outperforms the current VMR model. This conclusion was based on the following performance indication: excess dollars captured; erroneous rejections; erroneous requisitions captured; and, dollar savings based on a cost evaluation.

It is also recommended that the wholesale level release the average issue quantity when the MRQ is exceeded instead of issuing up to the MRQ. Validation procedures under SAILS should be rigorously defined and improved to insure proper identification of erroreous requisition at the retail level.

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CHAPTER I

INTRODUCTION

A single large requisition on the NICP, if completely filled, can put an item in a poor supply position. The effect is further compounded if the requisition is in error, as the customer receives and usually holds unwanted material thus needlessly tying up funds which he could put to better use. Provisions do exist for returning material when quantities exceed specified amounts but these rules are not always followed. On the other hand, if the customer receives a partial issue of a valid quantity, the readiness could be impaired or important programs delayed.

An effective method is required to identify a large requisition and to determine whether it is in error or necessary to maintain operational readiness or adequate stockage levels. An edit screen or Maximum Release Quantity (MRQ) can be used for this purpose. This screen would "flag" requisitions that are not within the norm thus permitting manual decisions on the validity and need of the quantity or a standard automated policy of rejecting portions of the quantity.

Currently the NICPs use a MRQ which is based on an empirical estimate of the variance to mean ratio (VMR) for each item (Ref 4). This study was originated because it was felt that the current screen was not effective enough in detecting erroneous requisitions. Additionally the model rejected many valid requisitions. The current VMR model allows each NICP to adjust the percentage of requisitions rejected by the MRQ screen. There exists little guidance for determining what is a reasonable rate.

Installations operating under the SAILS system incorporate a dollar check on the extended price of the requisition. While more useful as a means of financial control, to a limited degree the dollar check serves as a large quantity edit.

An analysis of the requisition processing system indicated that effective screens at both the intermediate and wholesale levels would be desirable. This will allow for verbal validation of requisitions flagged

by a retail model which is not feasible at the wholesale level. Additionally valid large requisitions can be detected and coded to prevent rejections by the NICPs. Illogical rejections by the NICPs erode confidence in the supply system and lead to costly procedures used by field units to obtain needed material. Such a procedure is the practice of submitting several requisitions to obtain a desired quantity thus avoiding NICP rejects. A sophisticated retail supply management system such as SAILS makes it possible to incorporate mathematical models with various parameters as a large quantity edit.

The 1st COSCOM, Ft. Bragg, NC was chosen for testing these concepts and models for two reasons. First, the SAILS system at the COSCOM was operating with little difficulty and second, it supported DSS units operating with NCR-500, DLOGS, and manual systems.

CHAPTER II

MODELS EXAMINED

The following is a discussion of models tested for effectiveness in capturing erroneous requisitions. Other models were developed but later rejected because of difficulty in implementation due to lack of data or complexity in computing the necessary parameters. Several of the models are adaptations of screens used or studied by other Services (Ref 7). There are 3 basic characteristics of the following models. The model can protect stockage levels by using as one of the parameters the average monthly demand. A second characteristic is to have a model which identifies large quantities based on the the items average issue quantity. This identification thereby protects the levels from an out of stock situation. A third parameter, unit price, is used to modify the MRQ because of the adverse effect of high price errors. As will be discussed later, a model which first identifies a large requisition outperforms a model solely designed to protect stocks.

Model 1 - Variance to Mean Ratio model for the wholesale level.

$$VMR = \exp\left(\frac{11.354 \times \text{Ln (AYD)}}{18.2619 + \text{Ln (UP)}}\right)$$

$$MRQ = k \times (\max(3.93 \times VMR - 6.71,\ VMR)) \text{ for } VMR \leq 20$$

$$MRQ = k \times (2.6 \times VMR + 20) \text{ for } VMR > 20$$

where

AYD = worldwide annual yearly demand

UP = unit price

k = factor unique to each NICP to determine the percentage of rejects. AVSCOM currently uses .3 as was used in this study.

Model 2 - Variance to Mean Ratio model for the retail level. This model is identical to Model 1 except the AYD represents the local installations demand. A k of 1.0 was used.

Model 3 - Average Issue Quality model for the retail level.

$$MRQ = 5X\ AIQ$$

where

AIQ = average issue quantity for the item based on local demands.

Model 4 - Average Issue Quantity/Annual Dollar Value model for the retail level.

If $0 \le ADV < 400$	$MRQ = 15 \times AIQ$
$400 \le ADV < 4500$	$MRQ = 7 \times AIQ$
$ADV \ge 4500$	$MRQ = 3 \times AIQ$

Model 5 - Average Monthly Demand model for retail level.

$$MRQ = 3 \times \sqrt{VAR} + AMD$$

where

AMD = average monthly demand

VAR = variance of the items monthly demand

Model 6 - High Dollar model for retail level (ref 8).

Reject the requisition if dollar value exceeds \$2500 for ASL, \$1500 for fringe.

Model 7 - Geometric Average Issue model for wholesale level. This model is used to detect abnormally large requisitions by use of the item's average issue quantity. It is assumed that the issue quantities are distributed geometrically and the MRQ is set to be 3 standard deviations from the mean.

$$MRQ = MAX\ (3,\ 3 \times \sqrt{VAR} + AIQ)$$

where

$$VAR = AIQ \times (AIQ-1)$$

The MRQ is bounded below by 3 for those items with an AIQ of one.

Model 8 - Geometric Average Issue model for the retail level. This model is identical to model 7 except that the local demand is used in computing the AIQs.

CHAPTER III

COST EVALUATION

Statistics on the number of erroneous requisitions captured or filled are not adequate to determine the effectiveness of a model. For example, if a valid requisition is partially filled, the effects on the customer can be varied. Inability to fill backorders after partial issue is more critical and costly than not meeting the item's requisition objective.

A cost evaluator was developed to assign costs to each model operating separately and in tandem at both the retail and wholesale levels. The evaluator uses the customer's net assets (due in - due out + on hand), stock levels, demand rate, and the priority or need of the requisition.

Requisitions were placed into four categories to determine costs: valid quantities rejected, valid quantities not rejected, invalid quantities rejected, and invalid quantities not rejected. The determination of the validity of the requisition is discussed in Chapter IV. Costs are assigned depending on which level, retail or wholesale, action was taken on the requisition.

3.1 Valid Quantities Rejected - Retail

At the retail level, if the quantity on a requisition exceeds the MRQ, the document will be removed from the daily cycle and validated by the item manager as currently done under the SAILS High Dollar Review. Upon receipt of the daily rejections, the item manager will contact the originator of the requisition to determine the validity of the desired quantity. If the quantity is valid, a 2L advice code will be placed on the MILSTRIP requisition to prevent further rejection at the NICP.

Requisitions under this category are assigned a screening cost based on effective validation efforts by COSCOM personnel. Generally two E-5's, the item manager and originator, could handle the validation and a liberal estimate of four dollars per requisition was assigned according to the time involved to complete this procedure. Validation of the requisitions takes about 15 minutes at maximum.

3.2 Valid Quantities Not Rejected - Retail

Under this situation the document proceeds through the SAILS cycle with no manual intervention. Since there is not an error in the quantity, no cost is assigned to the model.

3.3 Invalid Quantity Rejected - Retail

The document will be rejected off-line for validation by the commodity manager. After determining the amount in error, the manager will first enter the corrected requisition into the next daily cycle and return a CS advice code to the originator for file correction. The cost associated with this will be the screening cost.

3.4 Invalid Quantity Not Rejected - Retail

Should a document with an erroneous quantity pass the retail MRQ screen, a holding cost is charged to the model as follows:

Let IQ = Invalid quantity

AYD = Customer annual yearly demand

UP = Unit price

$$\text{Holding cost} = .40 \times UP \times \frac{IQ}{2} \times \frac{IQ}{AYD}$$

The .40 x UP expression was obtained from an LMI study (Ref 5) which represents the cost to hold an item for one year. This figure represents storage, obsolescence, damage, and pilferage costs. The IQ/2 represents the average invalid quantity on hand during the period IQ/AYD, or that portion of year it takes to exhaust the excess material. The upper bound of this cost is the dollar value of the requisition.

3.5 Invalid Quantities Not Rejected - Wholesale

Costs are computed as in Section 3.4. When costing wholesale models or models operating in tanden at both levels, the holding cost is computed only once.

3.6 Valid Quantities Not Rejected or Invalid Quantities Rejected - Wholesale

No cost is assigned since all processing is fully automated at the NICP and these cases require no special attention.

3.7 Valid Quantities Rejected - Wholesale

At the wholesale level, that portion of requested quantity that exceeds the MRQ is rejected without manual intervention. The costs associated were broken out into four cases depending on the customer's net assets after the partial issue, the priority of the requisition, and the customers stockage policy (fringe or ASL). The first three cases discussed are for replenishment requirements.

Case 1: If the customer's assets after the rejection are still above the reorder point, any due outs can be satisfied. Therefore, the unit will be effectively operating with a non-optimal EOQ for that item. A cost can be associated with this situation. (Ref 6).

$C(Q)$ = Cost per item when ordering Q units

λ = Cost of waiting one year for one requisition (Ref 1, 3)

OC = Cost to order ($10)

H = Cost to hold for one year (.40 x UP)

B = Expected number of backorders per year given R,Q (Ref 2)

AYD = Annual yearly demand for the item

QA = Quantity received - reorder point + assets before rejection

Q^* = Economic order quantity

Q = Actual quantity received

AIQ = Customer's average issue quantity

Then

$$C(Q) = \left(\frac{\lambda}{AIQ} \times \frac{B}{360} \times \frac{Q}{AYD} + OC + \frac{Q}{2} \times \frac{Q}{AYD} \times H\right)/Q$$

The first portion of the expression, $\frac{\lambda}{AIQ}$ x B/360 x Q/AYD, is the cost the customer incurs due to backorders when ordering Q units. The second, Q/2 x Q/AYD x H is the holding cost for a Q order. Therefore, the effect of ordering a non optimal Q is:

$$\text{Cost} = \text{Min } [[C(Q) - C(Q^*)] \times Q, \text{ OC}]$$

The cost is constrained to the cost to order, since the customer could always reorder for the rejected quantity.

<u>Case 2</u>: If the net assets after rejection are above zero but below the reorder point, the customer is still able to fill backorders but must reorder immediately since he is below the reorder point. A cost to order is charged to the model.

<u>Case 3</u>: If the assets after rejection are below zero after the partial issue, the customer is unable to fill backorders and additionally he will have to reorder immediately since he is below the reorder point.

$$\text{Cost} = \$10 + \frac{ASA}{AIQ} \times \frac{\lambda}{360} \times 15 \text{ days}$$

ASA = Assets after rejection

The $\frac{ASA}{AIQ}$ x λ/360 is the days wait cost for backorders. This is multiplied by 15 days since it takes a requisition four days to process through the SAILS system and approximately eleven days to process through the NICP and return a CS notice at which time the customer reorders.

<u>Case 4</u>: The cost of rejecting high priority or fringe requisitions is:

$$\text{Cost} = OC + \frac{QREJ}{AIQ} \times \lambda/360 \times 15 \text{ days}$$

QREJ = quantity rejected

The underlying assumption is that a high priority or fringe requisition is for material needed immediately for end item use. Therefore, the customer incurs a days wait cost for the entire rejected quantity.

A perfect wholesale model, one which catches all erroneous quantities and rejects no valid requisitions, will have a cost of zero dollars. A perfect retail screen will cost the number of erroneous requisitions times the screening cost.

CHAPTER IV

VALIDATION

If a requisition failed either a retail or wholesale model, the quantity was validated by on-site visits to the originator of the requisitions. For ASL items, the reorder point, requisition objective, and net assets were checked to determine if the quantity was justified. At the manual DSU, arithmetic calculations were verified. When available, the demand base used in the levels computation was checked to determine if abnormal demands radically changed the requisition objective.

Validation of non-stocked requisitions required additional efforts. The first step was to determine from unit records the type and number of aircraft for which the requisition was submitted. Technical manuals were next consulted to determine the quantity of that particular part on the aircraft. The product of these two numbers represents the maximum quantity needed. Amounts greater were considered in error. In situations where the customer was ordering parts for a fleet of aircraft, density figures, along with the number of parts per aircraft were used to determine the maximum number of parts needed.

As a result of this validation effort, the following list represents the type of errors discovered.

a. Using the incorrect number of parts/aircraft

b. Intentional ordering above the requisition objective

c. Using incorrect aircraft densities when ordering for a fleet of aircraft

d. Ordering above the PLL authorized quantity

e. Arithmetic errors in computing stock levels

f. Clerical errors

g. Keypunch errors

CHAPTER V

TESTING

One and one-half months of AVSCOM requisitions from the 1st COSCOM, Ft. Bragg, NC, were used as input to the evaluator. These requisitions originated primarily from three DSUs and their customers. Each of the DSUs used a different operating system - NCR 500, DLOGS, and manual.

Any requisition failing either a retail or wholesale model would be validated to determine the correct quantity. For these items, the customer's reorder point, requisition objective and net assets were recorded for use in the evaluator. For fringe requisitions the only information needed was the correct quantity.

There were a total of six retail and two wholesale MRQ models initially. Based on initial evaluator results for 655 requisition for models operating at one level (Fig 1), the total number of models for final consideration was reduced to four: Geometric model at the wholesale and retail levels, the current VMR model for wholesale and the retail high dollar screen. The current models were included in the final test to provide a base for determining improvements over the current editing system. The following three configurations of models operating at both levels were tested on the complete data base of 1129 requisitions.

a. Use of the dollar value check at the retail level, and the geometric model at wholesale.

b. Geometric model for ASL items at the retail, dollar check for fringe; and use of the geometric model at the wholesale.

c. Dollar check at the retail level, and the present VMR model at the wholesale level.

With these three model configurations, three rejection policies for wholesale models were tested. First, the current method is to reject only quantities in excess of the NICP's MRQ. An alternative would be to release the average issue quantity when the original request exceeded the MRQ. A third policy would reject the entire quantity if it exceeded the MRQ and the unit price of the item was greater than $100; otherwise issue up to the MRQ. Unit prices of 0 - $1500 dollars were tested in the cost evaluator for this policy to arrive at the optimum dollar figure.

FIGURE 1

Cost based on 655 items for models operating at either retail or wholesale level. There are 16 errors for a total dollar value of $11,712.

	MODEL	LOCATION	EVALUATOR COST	EXCESS DOLLARS CAPTURED
1	VMR	Wholesale	3091	7.00
2	VMR	Retail	2547	16.44
3	AIQ Multiple	Retail	2567	1952.00
4	AIQ, Dollar Strat	Retail	2535	2833.00
5	AMD	Retail	3042	17.00
6	SAILS Dollar	Retail	2995	2822.00
7	Geometric	Wholesale	789	9512.00
8	Geometric	Retail	772	9654.00

CHAPTER VI

RESULTS

The final performance measures are given for three model configurations operating with three rejection policies of the wholesale level (Fig 2). Figure 3 details number of requisitions in error, invalid rejections, and erroneous rejections for the three basic model configurations.

At the retail level, the use of a geometric model based on installation demand for stocked items far outperforms the dollar check currently used. While both models screened approximately the same percentage of requisitions, the geometric model captured more erroneous requisitions and identified those which would have been subsequently rejected by the wholesale screens.

The geometric model at the wholesale level performed better than the current VMR screen based on:

a. Evaluator cost
b. Excess dollar captured
c. Erroneous requisitions identified
d. Invalid rejects

This model rejected more ASL items and fewer fringe items, but the combined percentages of requisitions rejected were lower than the current VMR screen.

Tbe VMR screen at the wholesale level is less restrictive for items with large world wide demands then for less active items. This is exhibited by the poor performance of the VMR screen with the ASL items. For fringe requisitions, approximately the same dollar value of errors was captured as the geometric screen, but the VMR model rejected more valid requisitions.

Screening based on the dollar value of the requisitions is basically ineffective in catching most errors. Its usefulness, though, is in catching these errors which would have severe financial impact on the customer. This was the only model tested for fringe items at the retail level.

MODELS	* POLICY	EVALUATOR COST	DOLLAR VALUE OF ERRORS CAPTURED	PERCENT OF DOLLAR VALUE OF ERRORS CAPTURED
Geometric-Wholesale/Geometric-Retail $1500 Fringe-Retail	P1	580.13	12993.46	79%
Geometric-Wholesale/$2500 ASL-Retail $1500 Fringe-Retail	P1	996.11	11290.58	68%
Geometric-Wholesale/Geometric-Retail $1500 Fringe-Retail	P2	358.25	15206.67	92%
Geometric-Wholesale/$2500 ASL-Retail $1500 Fringe-Retail	P2	671.25	14357.26	88%
Geometric-Wholesale/Geometric-Retail $1500 Fringe-Retail	P3	336.18	15442.28	99%
Geometric-Wholesale/$2500 ASL-Retail $1500 Fringe-Retail	P3	522.26	15098.00	92%
VMR-Wholesale/$2500 ASL-Retail $1500 Fringe-Retail	P1	3524.33	4191.36	25%

*P1 - Issue up to MRQ
P2 - Issue AIQ
P3 - Issue MRQ - UP < $100
Issue 0 - UP ≥ $100
Total Dollar Value of Errors - $16,397.90

FIGURE 2

RESULTS - 1129 ASL AND FRINGE

	RETAIL % SCREENED	RETAIL ERRORS CAUGHT	WHOLESALE % SCREENED	WHOLESALE ERRORS CAUGHT	ERRONEOUS REJECTIONS	TOTAL ERRORS CAUGHT	TOTAL ERRORS
Current System VMR at Wholesale/ $ Screen at Retail	4.4	4	2.8	8	22	12	29
Geo Wholesale/ Geo Retail, ASL $ Screen for Fringe	4.3	14	1.9	10	11	24	29
Geo Wholesale/ $ Screen Retail	4.4	4	2.4	18	17	22	29

1129 ASL and Fringe Items
29 Errors

FIGURE 3

Other fringe models needed data that was not feasibly available in the SAILS system. The use of this screening criterion for non-stocked items is better than no screen.

The ranking of the best reject policy at the NICP was independent of the model configuration used. To reject the entire requisition if the MRQ was exceeded and the unit price of the item was greater than $100 resulted in lower evaluator costs and higher excess dollars captured.

Issuing the AIQ, however, is more reasonable to implement. A complete rejection would affect operational readiness especially when the request is for a non-stocked item. Additionally such a policy would cause a great deal of dissatisfaction among retail supply personnel. The evaluator costs for the two policies are not significantly different to discount the adverse effects at the retail level.

CHAPTER VII

RECOMMENDATIONS AND CONCLUSIONS

Based on the results presented, the best editing system is a geometric model at the wholesale for all items and at the retail level for ASL lines. Use of the retail dollar check for the fringe items should be continued. As previously stated, the most viable rejection policy for wholesale models would be to issue the AIQ when a requisition exceeded the MRQ.

It is recognized that implementation of a geometric model in the SAILS system may not be immediately accomplished due to current workload imposed on SAILS system personnel.

In order to incorporate the model into SAILS, the MRQ will be stored on the Availability Balance file and updated everytime a supply control study is run. Until such changes can be made, the dollar screen will suffice as an edit screen.

The entire edit system design depends on accurate validation at the retail level. Currently these procedures are ineffective because no precise guidelines have been established. Work should be initiated to better define procedures for validation. This action alone would greatly improve the current editing system.

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1	Commander, US Army Aviation Systems Cmd, ATTN: DRSAV-D, P.O. Box 209, St. Louis, MO 63166
1	Commander, US Army Electronics Cmd, ATTN: DRSEL-SA, Ft. Monmouth, NJ 07703
1	Commander, US Army Test & Evaluation Cmd, ATTN: DRSTE-SY, Aberdeen Proving Ground, MD 21005
1	Commander, US Army Armament Cmd, ATTN: DRSAR-SA, Rock Island, IL 61201
1	Commander, US Army Troop Support Command, ATTN: DRSTS-G, 4300 Goodfellow Blvd, St. Louis, MO 63120
1	Commander, US Army Mobility Equipment Research & Development Cmd, ATTN: DRXFB-O, Ft. Belvoir, VA 22060
1	Commander, US Army Natick Research & Development Cmd, ATTN: DRXNM-O, Natick, MA 01760
1	Commander, USA Missile Cmd, ATTN: DRSMI-C, Redstone Ars, AL 35809
1	Commander, USA Missile Cmd, ATTN: DRSMI-D, Redstone ARS, AL 35809

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1	Commander, USA Armaments Research & Development Cmd, Implementation Task Force, ATTN: DRCSA-RP-SE (Mr. Larry Ostuni) Picatinny Arsenal, Dover, NJ 07801
1	Commander, US Army Depot Systems Command, Letterkenny Army Depot, Chambersburg, PA 17201
1	Logistics Control Activity, Presidio of San Francisco, CA 94120